COMPARATIVE CHART OF THE VERTEBRATE SKULL.*

CHARLES S. MEAD.

In compiling the following chart, an attempt has been made to show the history of the cranial bones in the different classes of vertebrates. To make it general as well as specific from one to four types are given under each class, and where possible, an unspecialized and a highly specialized form have been taken. As a rule, the same bone occurs in the different classes of vertebrates, but it may fail to develop, as in the Amphibians, or several bones may fuse to form larger elements, as in the Mammals, and it is the purpose of this chart to show these irregularities.

In the higher types, especially the birds, there is a great tendency for bones that are separate in the immature stages to fuse in the adult, the sutures being obliterated. In Lacerta and the Amphibia many elements that are indicated as bones remain cartilaginous. Where two or more bones in one type fuse to form one bone in another type the line between them has been omitted.

In the Urodeles, Ophidians, and Chelonians no particular type has been taken.

Different authors have used different names for the same bone in the same class or different classes, or the same name may be used for as many as four different bones. Below is given a list of synonyms:

Jugal, malar, zygoma, zygomatic.
Quadrato-jugal, zygomatic.
Squamosal, supratemporal of Ophidians.
Supra-angular, surangular.
Coronoid, coronary.
Lacrymal, supraorbital.
Sphenotic, postfrontal.
Prootic, petrosal.
Periotic, petrosal of Mammals.
Epipterygoid, columella.
Transverse, ectopterygoid, transversum, transpalatine.
Pterygoid, ectopterygoid.
Mesopterygoid, entopterygoid.
Mesethmoid, ethmoid, supra-ethmoid, median ethmoid.
Ectoethmoid, ectethmoid, parethmoid, lateral ethmoid.
Turbinal, ectoethmoid.
Maxilla, maxillary, supermaxilla, superior maxilla.
Premaxilla, intermaxilla, anterior maxillary, incisive.

* From the Zoological laboratory of the Ohio State University.

The pterotic has been called the squamosal, but the latter arises from a separate ossification and is not present in fishes. The turbinals are derived from outgrowths of the bones surrounding the nasal chamber and represent true ossifications in Mammals, but may remain cartilaginous in the lower groups. They are first recognized in the Amphibians, where they are merely cartilaginous protuberances on the bones of the floor and side walls of the nasal chamber.

Characteristics of the different classes :

FISH.—One occipital condyle. Opercles present only in the fish. Some fish have bones which are lacking in others, there being a great difference between some of the families in this respect.

AMPHIBIANS.—Two occipital condyles ; no trace of supra- or basioccipitals. The skull is remarkable for the extent to which the chondrocranium is retained and the consequent small number of primary bones. The prootic alone forms the auditory capsule in the frog, the other otic ossifications not being developed ; in the Urodels an opisthotic is added.

REPTILES.—One occipital condyle. The transverse is present in all reptiles, except the turtles, and in no other vertebrates. The zygomatic arch, formed by the quadrato-jugal and the jugal, is wanting in the Ophidians. In turtles there are no teeth, and the basisphenoid is the only one of the sphenoidal bones present. Of the otic bones the prootic is always distinct, the epiotic is fused with the supraoccipital, while the opisthotic (free in turtles) is usually united to the exoccipital.

BIRDS.—One occipital condyle. The bones of the cranium fuse early so that the sutures between them are obliterated. Teeth are lacking in modern birds. The anterior end of the parasphenoid forms the rostrum and the posterior the basitemporal.

MAMMALS.—Two occipital condyles. The lower mandible articulates with the squamosal and is composed of five elements on each side, as the articular has been taken into the middle ear to form the malleus. The quadrate has gone into the ear and become the incus. The stapes is derived from the hyomandibular and from some membranous elements.

EXPLANATION OF PLATES III AND IV.

S=Salmon; F=Frog; U=Urodele; L=Lacerta; O=Ophidian; T=Turtle; A=Alligator ; D=Duck ; P=Pigeon ; C=Chicken ; H=Dog ; R=Rabbit ; M=Man. In the first column after the name of the bone, c=cartilage bone and m=menbrane bone.

OHIO NATURALIST. *Plate III.*

		Fish.	Amphibian.	Reptile	Bird	Mammal.	
Inter parietal	m					HR	Occipital M (Interparietal–Basioccipital)
Supraoccipital	c	S		LOTA	DPC	HR	
Exoccipital	c	S	FU	LOTA	DPC	HR	
Basioccipital	c	S		LOTA	DPC	HR	
Paroccipital				LOA			
Quadrato-jugal	m		F	TA	DPC		
Jugal	m	S	FU	LTA	DPC	HRM	
Squamosal	m		FU	LOTA	DPC	HR	Temporal in M (Squamosal–Prootic)
Tympanic	m					HR	
Sphenotic	c	S		LOTA		Periotic HR (Sphenotic–Prootic)	
Pterotic	c	S					
Opisthotic	c	S	U	LOTA	Periotic DPC (Opisthotic–Prootic)		
Epiotic	c	S		LOTA			
Prootic	c	S	FU	LOTA			
Opercle	m	S					
Pre-opercle	m	S					
Inter-opercle	m	S					
Sub-opercle	m	S					
Metapterygoid		S					
Mesopterygoid		S					
Basipterygoid				LO	DPC		
Epipterygoid				LA			
Transverse				LOA			
Symplectic		S					
Supra-temporal	m			L			
Orbitals	m	S					
Lacrymal	m			LA	DPC	HRM	

Chas S Mead

MEAD on the "Vertebrate Skull."

OHIO NATURALIST. *Plate IV.*

	Fish	Amphibian	Reptile	Bird	Mammal
Pterygoid c	S	FU	LOTA	DPC	HR (Sphenoid in M)
Alisphenoid c	S	FU	LA	DPC	HR
Basisphenoid c	S		LTAO	DPC	HR
Presphenoid c		Sphenethmoid FU	LO	DPC	HR
Orbitosphenoid c	S			DPC	HR
Mesethmoid c	S		LOA	DPC	Ethmoid HRM
Ectoethmoid	S			DPC	
Parasphenoid m	S	FU	LO	DPC Rostrum; DPC Basitemporal	
Turbinal c			LOTA	DPC	HRM
Frontal m	S	U Fronto-parietal in F	LOTA	DPC	HRM
Parietal m	S	U	LOTA	DPC	HRM
Prefrontal m		U	LOA Prefronto-nasal in T		
Nasal m	S	FU	LOA	DPC	HRM
Maxilla m	S	FU	LOTA	DPC	HR M
Premaxilla m	S	FU	LOTA	DPC	HR
Palatine c	S	FU	LOTA	DPC	HRM
Vomer m	S	FU	LOTA	DPC	HRM
Supra-angular m			LTA	DPC (Fused in adult)	Inferior Maxillary HRM
Coronoid m			LOTA	DPC	
Splenial m		FU (Fused in adult)	LOTA	DPC	
Dentary m	S	FU	LOTA	DPC	
Angular m	S	FU	LOTA	DPC	
Articular c	S	FU	LOTA	DPC	HRM Malleus
Meckel's cartilage c	S	F			
Quadrate c	S	FU	LOTA	DPC	HRM Incus
Hyomandibular c	S	F Columella	LOTA	DPC	HRM Stapes

Chas. S. Mead

MEAD on the "Vertebrate Skull."

THE RELATIONSHIP OF VARIATION TO ENVIRONMENT IN CHRYSANTHEMUM LEUCANTHEMUM.

L. B. WALTON.

(Abstract.)

It is not sufficient to show that a particular species possesses a certain index of variability in a restricted locality. We must attempt to ascertain the component stimuli forming the environment and learn the effect which each group of stimuli has on the variability of the organism in question. Only by so doing can we draw accurate conclusions concerning the factors of evolution.

While natural environment does not furnish us with the best conditions for the solution of the problem, a study of the variability exhibited by two groups of *Chrysanthemum leucanthemum* (the common white daisy) has brought to light some facts of considerable interest.

In a comparison of two groups of 500 each, obtained on the same day from localities less than a mile apart, it was found that the group having the greater nourishment had the greater variability as measured by the "index of variability"

$$\left(\sqrt{\frac{\Sigma(x^2 f)}{n}}\right)$$

the "average deviation"

$$\left(\frac{\Sigma(x.f)}{n}\right)$$

and the amplitude or range of variation. Thus the data obtained in this particular study suggest that the difference in variability is dependent on food supply, or, in other words, that chemical stimuli are one of the underlying factors producing variability. This is a conclusion that has been previously suggested but not definitely established by statistical methods.

It is evident that there is a need for further investigation in this direction on animals as well as plants, for only by the careful application of statistical methods can the fundamental principles of evolution be ascertained.

Kenyon College.

FURTHER FLORISTIC STUDIES IN WEST VIRGINIA.

W. A. KELLERMAN.

(Abstract.)

An account of a collecting trip through portions of Randolph and Webster Counties, especially in the Cheat and Point Mountains, with brief outline of the more conspicuous and interesting fungi—several of which are now reported for the first time.

ADDITIONAL INFECTION EXPERIMENTS WITH SPECIES OF RUSTS.

W. A. KELLERMAN.

(*Abstract.*)

General report of artificial cultures of Rust stages, both heteroecious and autoecious species, continuation of work reported the previous year. Over twenty species were used and inoculations of a very large number of host-plants were attempted. The experiments numbered nearly two hundred. In nine cases positive results were obtained—some being repetitions of previous successful experiments, others showing connections not previously known.

Of the latter it was shown that the Black Rust (Puccinia muhlenbergiae Arth.) on the common Muhlenberg Grass (Muhlenbergia mexicana) was the alternate stage of the Yellow Cluster-cup fungus (Aecidium hibisciatum Schw.) on the Marsh Mallow (Hibiscus moscheutos).

Cultures with the Black Rust (Puccinia cirsii-lanceolati Schroet.) of the Common Thistle (Carduus lanceolatus L.) resulted in the development of aecidia or Yellow Cluster-cup stage (as well as the red and black spores) but this has not before been reported in this country. The Rust has heretofore been called Piccinia cirsii Lasch, but the experiment showed it to be P. cirsii-lanceolati, a species described in Europe several years ago by Schroeter.

In a similar manner it was proven that the Western Sage Rust (Puccinia caulicola Tr. & Gall. on Salvia lanceolata)—material for cultures received from Kansas in the early spring (sent by Mr. E. Bartholomew)—has a hitherto unrecorded aecidial stage on the same host plant.

Cultures demonstrated experimentally for the first time the aut-eu-puccinial character of the Rust of Ruellia. That is to say, all of the four stages grow on one and the same host.

The paper is published in full in the December number of the *Journal of Mycology*. A summary of the successful cultures may be briefly stated thus, it being understood that the teleuto-spores (black or winter spores) were used when sowings were made on the host plants, and, in case of Puccinia lateripes, aecidiospores, also:

Puccinia angustata (on Scirpus atrovirens)—aecidia on Lycopus americanus.

Puccinia caulicola (on Salvia lanceolata)—aecidia on Salvia lanceolata.

Puccinia caricis-erigerontis (on Carex festucacea)—aecidia on Leptilon canadensis.

Puccinia caricis-solidaginis (on Carex stipata)—aecidia on Solidago canadensis.
Puccinia cirsii-lanceolati (on Carduus lanceolatus)—aecidia on Carduus lanceolatus.
Puccinia helianthi (on Helianthus mollis)—aecidia on Helianthus annuus and H. mollis.
Puccinia hibisciata (on Muhlenbergia mexicana)—aecidia on Hibiscus moscheutos and H. militaris.
Puccinia lateripes (on Ruellia strepens)—aecidia, etc., on Ruellia strepens.
Puccinia subnitens (on Distichlis)—aecidia on Chenopodium album.